HST Instrument Development History

The table below provides some of the key milestone dates for the second and third generation HST science instruments (SIs), and is intended to show the range of development timescales encountered during the Program. Analysis of some key aspects of these "instrument histories" follows.

Table 1: Key Dates

Instrument	Selection	Contract Start	CDR	PER	Instrument SMGT	Ship Date	Launch
STIS	1985	Oct 90[1]	Feb 94	Jun 96	Nov 96	Dec 96	Feb 97
NICMOS	1985	Nov 90[2]	Feb 94	Apr 96	Oct 96	Dec 96	Feb 97
ACS	Jan 95	Apr 95	Apr 96	Sep 98	May 01	Dec 01	Mar 02
COS	Aug 97	Mar 98	Apr 00	Apr 03	Mar 04	Oct 04	Nov 04
WFC3	Mar 98	Nov 98	Dec 00	Sep 03	May 04	Oct 04	Nov 04

Notes:

[1]For STIS the date refers to the start of the Fiscal Year (FY) in which serious instrument design commenced, and not to the formal initiation of the prime contract (Oct 86), the first years of which proceeded very slowly in the immediate post-*Challenger* era. However, the STIS FY90 start-up was itself chaotic as a result of multiple re-designs and de-scopes occurring in response to HST Project's planning for the First Servicing Mission and the recovery from spherical aberration.

[2]The second sentence in Note 1 also applies at some level to NICMOS, for which much detector work had fortunately been done in advance.

Terminology/Acronym definitions:

Contract Start through CDR interval: instrument design phase
CDR=Critical Design Review (approximate start of fabrication, i.e., "cutting metal")
PER=Pre-Environmental Review (instrument fully assembled, submitted by Prime Contractor to Goddard for instrument and system-level Integration and Testing)
Instrument SMGT =Instrument Servicing Mission Ground Test (instrument is tested for compatibility with servicing mission and on-orbit operations commanding, marks end of instrument-level I&T. At this point the instrument is viewed as flight-ready.)
Ship Date=ship date to KSC shortly before launch; date determined by Shuttle launch schedule.

From the dates in the table above, several key intervals (in months) can be extracted:

Table 2: Key Intervals (months)

Instrument	Instrument Design (Contract start to CDR)	Instrument Fabrication (CDR to PER)	Integration & Test (PER to SMGT)	Total Instrument time (Contract thru SMGT)	Total Duration, Contract Start thru Ship to KSC
STIS	40	28	5	73	75
NICMOS	39	26	6	71	73
ACS	12	29	32	73	80
COS	25	36	11	72	79
WFC3	25	33	8	66	71

Analysis/Commentary

Given that the external factors (discussed below) which affected the development schedule of the five SIs were not identical, and that they affected the SIs at different times in their development, the uniformity of "total times" (last 2 columns) is remarkable. The interesting lessons, however, lie in the differences in the various intervals from one instrument to the next. The two "outliers" which are most obvious in Table 2 both belong to ACS: a short design phase (12) and a very long I&T program (32). The primary reason for the rapid design leading to CDR wasn't that ACS was inherently easier, but rather that the other SIs were all affected by servicing mission launch delays which stretched this phase of their total development. As indicated in the Notes to Table 1, STIS and NICMOS were hit hard by spherical aberration: not only were their installations into HST delayed substantially (to SM2, Feb. 1997), but their yearly funding was cut to pay for COSTAR and the extensive (aberration-induced) modifications to WFPC2. Likewise, the early design phases of COS and WFC3 were affected by the multi-year delay in SM4 caused by the early-1999 splitting of SM3 into SM3A & B.

Looking at the "Instrument Fabrication" column, once STIS and NICMOS got to CDR shortly after the Dec. 1993 First Servicing Mission, their builds went reasonably smoothly (27 months on average). The evidence from Table 2 is that ACS had a reasonably brief basic build (29) which was essentially complete by the time that SM3 was split—and ACS's mission, SM3B, was delayed two years to 3/2002. The fabrication phases of COS and WFC3 are somewhat longer than those of the other SIs, indicative of continuing stretch-out effects from the SM3A/B split.

ACS had a long I&T phase which was primarily driven by the SM3B delay. Notwithstanding that, ACS also had serious technical problems which were addressed during its extended I&T period. It is difficult to estimate when ACS would have been "flight-ready" if the Shuttle launch delays had not occurred. In contrast to the ACS experience, the other four SIs, having weathered the Shuttle world delays in previous phases, had "normal" instrument I&T durations of between 5 and 11 months (cf. Table 2).

To make the ACS point in the previous paragraph more general, none of this emphasis on the dominant effect of launch delays is meant to deny the existence of real, often challenging internal problems in instrument development (detectors, optical bench stability, mechanism re-work, etc.), problems which at some level will probably always be with us and can slow down instrument development even if all external factors are nominal. The point which cannot be made strongly enough, however, is *that no HST servicing mission launch was ever held up because an instrument wasn't ready*.

It is reasonable to ask what is possible when the major external factor—Shuttle mission delays—is not present. In the first two of three cases that follow, we make that assumption, but look at the separate situations of instruments with larger funding lines (STIS and NICMOS, despite the cuts) and those with constrained budgets (ACS, WFC3, COS). In the last scenario we look at what has happened most recently with COS and WFC3 where the pace of work has been influenced strongly by cash flow re-phasing resulting from slips to SM3B and SM4 launches.

Case 1: No Launch Delays—Fast-paced design, larger fabrication budget, nominal instrumental I&T

Design: 12 months (ACS)
Fabrication: 27 (STIS/NICMOS average)
I & T: 7 (STIS, NICMOS, COS, WFC3 average)
Total: 46

Case 2: No Launch Delays—Fast-paced design, constrained fabrication costs, nominal I&T

Design: 12 (ACS)
Fabrication: 29 (ACS)
I&T: 7 (4-instrument average)
Total: 48

Case 3: Launch Delays—Slowed design, constrained/slowed fabrication, slower I&T pace

Design: 25 (COS, WFC3)
Fabrication: 35 (COS, WFC3 average)
I&T: 10 (COS, WFC3 average)
Total: 70

It certainly is true that the front-end procurement (acquisition) phase has not been included in the above Tables and Cases, and in an AO procurement this can add a year(+) to the total. Taking this into account, an instrument cycle of ~ 5 years still does seem credible, even in the present era of constrained instrument budgets. Either a non- or a modified AO process would presumably be able to shave significant "overhead" off the front end.

It is now mid-2003. Realistically, SM4 is looking like a mid-2005-to-early-2006 proposition, which would make any SM5 not a 2007 activity, but more likely a 2009 one.